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CUBIC-FOOT VOLUME TABLES AND EQUATIONS FOR YOUNG-GROWTH WESTERN HEMLOCK AND SITKA SPRUCE IN SOUTHEAST ALASKA

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ABSTRACT

Cubic-foot volume tables and equations are given for young-growth western hemlock and Sitka spruce, based on d.b.h. and number of logs to a merchantable top.

KEYWORDS: Western hemlock, *Tsuga heterophylla*, Sitka spruce, *Picea sitchensis*, volume tables (log), volume measurement (tree).

The cubic-foot volume tables presented here for young-growth (less than 150 years old) western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) supplement the tables presented in 1965 by Embry and Haack.[1/] They are based on d.b.h. (D) and log height (H) because timber cruisers in the Alaska Region generally estimate log heights instead of total height for sawtimber trees. The earlier tables did not contain cubic-foot volumes based on log heights.

METHODS

The basic data used to develop these cubic-foot tables consisted of measurements from 217 Sitka spruce and 160 western hemlock trees larger than 10.5 inches in diameter at breast height. Trees with diameters up to 38 inches for spruce and 26 inches for hemlock were used. Tree heights ranged from 51 to 170 feet for spruce and from 58 to 149 feet for hemlock.

Smalian's formula was used to compute cubic-foot volume for 16.3 foot logs[2/] between the top of the butt log and the 4-inch top, inside bark. For the butt log additional measurements were used so that its volume could be more accurately determined. In addition to measurements of inside bark diameter at the top and bottom of the log, measurements were also taken inside bark at breast height and at the midpoint of the log. The sum of the volumes of all the logs of a tree was the volume used to derive values in the tables.

Weighted linear regression was used to develop a volume prediction equation for each species. The model used was V=f(D,H), with each observation assigned a weight inversely proportional to observed $(D^2H)^2$. Weighting was accomplished by multiplying both sides of the model by $(D^2H)^{-1}$, giving the transformed model:

$$V(D^2H)^{-1} = f(D,H)(D^2H)^{-1}$$

where D = d.b.h., H = number of logs

The actual equation used in stepwise regression was:

$$\frac{V}{D^2H} = b_o + \frac{b_1}{D^2H} + \frac{b_2}{DH} + \frac{b_3}{H} + \frac{b_4}{D^4H}$$

and the final untransformed solutions were:

Spruce

$$V = 0.048534D^2H + \frac{507.72}{D^2}$$

Hemlock

$$V = 5.2132 + 0.045805D^2H$$

Cubic-foot volume tables prepared from these equations along with their precision are given in tables 1 and 2.

[1/] Embry, Robert S., and Paul M. Haack. 1965. Volume tables and equations for young-growth western hemlock and Sitka spruce in southeast Alaska. USDA For. Serv. Res. Note NOR-12, 21 p. North. For. Exp. Stn., Juneau, Alaska.

[2/] Includes 0.3-foot trim allowance.

Table 1--*Cubic-foot volumes (1-foot stump to a 4-inch top, d.i.b.) by d.b.h. and number of logs to a 40-percent top,*[1] *Smalian's formula, for young-growth western hemlock, southeast Alaska*[2]

D.b.h.[3] (inches)	Height (number of logs)[1]										Basis: trees measured[4]
	1	2	3	4	5	6	7	8	9	10	
11	10.8	16.3	21.8	27.4	32.9	38.5					17
12	11.8	18.4	25.0	31.6	38.2	44.8	51.4				30
13	13.0	20.7	28.4	36.2	43.9	51.7	59.4				19
14	14.2	23.2	32.1	41.1	50.1	59.1	68.1	77.0			9
15	15.5	25.8	36.1	46.4	56.7	67.0	77.4	87.7			18
16	16.9	28.7	40.4	52.1	63.8	75.6	87.3	99.0			20
17	18.5	31.7	44.9	58.2	71.4	84.6	97.9	111			8
18	20.1	34.9	49.7	64.6	79.4	94.3	109	124			15
19		38.3	54.8	71.4	87.9	104	121	138			8
20		41.9	60.2	78.5	96.8	115	134	152			6
21		45.6	65.8	86.0	106	126	147	167			4
22		49.6	71.7	93.9	116	138	160	183			1
23		53.7	77.9	102	126	151	175	199			0
24		58.0	84.4	111	137	164	190	216			1
25		62.5	91.1	120	148	177	206	234			3
26			98.1	129	160	191	222	253	284		1
27			105	139	172	206	239	272	306		0
28			113	149	185	221	257	292	328		0
29			121	159	198	236	275	313	352		0
30				170	211	253	294	335	376	417	0
31				181	225	269	313	357	401	445	0
32				193	240	287	334	380	427	474	0
33				205	255	304	354	404	454	504	0
34				217	270	323	376	429	482	535	0
35				230	286	342	398	454	510	566	0

[1] Number of 16.3-foot logs between 1-foot stump and a top equaling 40 percent of d.b.h., but not less than 6.0 inches inside bark.

[2] Based on weighted regression: $V = 5.2132 + 0.045805D^2H$. Standard error of estimate = 5.23 cubic feet or 7.28 percent of the mean volume.

[3] Diameter classes are midpoint; e.g., 11-inch class includes 10.6 to 11.5 inches.

[4] Number of trees; range of data for 160 trees enclosed by solid lines.

Table 2--*Cubic-foot volumes (1-foot stump to a 4-inch top, d.i.b.) by d.b.h. and number of logs to a 40-percent top,*[1] *Smalian's formula, for young-growth Sitka spruce, southeast Alaska*[2]

D.b.h.[3] (inches)	Height (number of logs)[1]										Basis: trees measured[4]
	1	2	3	4	5	6	7	8	9	10	
11	10.1	15.9	21.8	27.7	33.6	39.4	45.3				25
12	10.5	17.5	24.5	31.5	38.5	45.5	52.4				16
13	11.2	19.4	27.6	35.8	44.0	52.2	60.4				24
14	12.1	21.6	31.1	40.6	50.2	59.7	69.2	78.7			15
15	13.2	24.1	35.0	45.9	56.9	67.8	78.7	89.6			19
16	14.4	26.8	39.3	51.7	64.1	76.5	89.0	101			17
17	15.8	29.8	43.8	57.9	71.9	85.9	99.9	114			14
18	17.3	33.0	48.7	64.5	80.2	95.9	112	127			18
19	18.9	36.4	54.0	71.5	89.0	106	124	142			11
20	20.7	40.1	59.5	78.9	98.3	118	137	157			3
21	22.6	44.0	65.4	86.8	108	130	151	172			12
22		48.0	71.5	95.0	118	142	166	189			6
23		52.3	78.0	104	129	155	181	206	232		9
24		56.8	84.7	113	141	169	197	224	252		6
25			91.8	122	152	183	213	244	274		5
26			99.2	132	165	198	230	263	296		2
27			107	142	178	213	248	284	319		4
28			115	153	191	229	267	305	343		3
29			123	164	205	246	286	327	368		1
30				175	219	263	306	350	394	437	4
31				187	234	280	327	374	420	467	1
32				199	249	299	348	398	448	497	0
33				212	265	318	370	423	476	529	0
34				225	281	337	393	449	505	561	1
35				238	298	357	417	476	536	595	0

[1] Number of 16.3-foot logs between 1-foot stump and top equaling 40 percent of d.b.h., but not less than 6.0 inches inside bark.

[2] Based on weighted regression: $V = 0.048534D^2H + \frac{507.72}{D^2}$. Standard error of estimate = 7.51 cubic feet or 7.93 percent of the mean volume.

[3] Diameter classes are midpoint; e.g., 11-inch class includes 10.6 to 11.5 inches.

[4] Number of trees; range of data for 216 trees enclosed by solid lines. One tree not shown in the "Basis" column was in the 38-inch diameter class.

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